Effects of Increased Highway Capacity: Results of Household Travel Behavior Survey

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Travel behavior is likely to change when road congestion and travel times are improved as a result of new highway capacity. The behavioral change is complex and may manifest itself over both the short and long run. Short-term impacts may include changes in route choice, time of day that trips are made, mode choice, trip frequency, trip chaining, and destination choice. Longer-term impacts may include changes in automobile ownership, residential location, choice of workplace location, and land development patterns. These changes occur against a background of economic, demographic, and pricing changes affecting the population as a whole. A fresh approach is taken to illuminate the question of whether highway improvements induce new travel. The research has been framed in terms of relating the time "released" by a highway improvement to how households would use this time. The question then becomes, Do travelers use the time saved to make more (or longer) trips, or do they use it for other activities? To make the responses more realistic, respondents were asked to relate hypothetical changes in congestion levels to their previous day's travel and activity patterns. The results of a stated preference/activity survey of nearly 700 urban Californians indicate that congestion-relieving projects are likely to induce a small (3 to 5 percent) but not trivial increase in trip generation. This effect could be accounted for by modifications in the traditional "four-step" travel forecasting models, which gives transportation and air quality analysts a better sense of how to assess the potential induced travel impacts of new highway capacity.

Few current transportation issues engender more controversy than the effects of new highway capacity on traffic and travel demand. The purpose of adding highway capacity is to reduce traffic congestion and improve automobile travel times and, in some cases, air quality. These changes, in turn, affect travel behavior by affecting peoples' choice of modes of travel, their choice of destination, and their choice of travel route. Less well known is how travel time changes caused by capacity increases may affect total travel demand, especially trip generation (i.e., the number of vehicle trips made per person or per household). Estimating the magnitude of this effect on trip generation is particularly uncertain. A primary purpose of this project was to examine the effects of new capacity on trip generation, because in most North American travel forecasting models, trip generation is not sensitive to transportation supply variables.

IMPORTANCE TO CLEAN AIR AND TRANSPORTATION

Federal, state and local governments spend billion dollars a year on new road improvements to reduce congestion, improve safety, and provide for economic development. There is popular and some professional opinion that new capacity in urban areas is eventually swamped by new demand so that in the end motorists are no better off than they were before the improvement was made (*1,2*). Disagreements arise about whether this effect exists and, if it does, what its magnitude is. The issue has moved to center stage because the 1990 Clean Air Act Amendments prohibit recipients of federal transportation funds from constructing projects that worsen air quality in nonattainment areas.

A road improvement may improve air quality depending on whether a trip-inducing effect occurs. New road capacity, to the extent that it reduces speed variations (stop-and-go driving) and allows vehicles to travel a steady 30 to 45 mph (48 to 72 kph), improves air quality. This claim has been challenged by others, who maintain that any air quality benefit of new road capacity in the short term will be offset in the longer term by increased travel demand that will nullify any improvement in total emissions. Of course, the trip induction effects of new highway capacity do not have to be 0 for there to be a net air quality benefit, but they must be smaller than the increase in emissions per vehicle.

STUDY PURPOSE AND RESEARCH APPROACH

The purposes of this study were to answer two fundamental questions: Do capacity increases increase trip making? If so, what is the magnitude of this increase, if it exists? The overall research objectives were accomplished through a variety of means; this paper reports on the results of a household survey of traveler behavior conducted as part of the study. Past attempts to assess the travel impacts of new highway capacity have mostly relied on before-and-after traffic volume comparisons. In some cases traffic counts have been supplemented with roadside interview or home interview surveys. A few investigators have attempted to fit regression models for predicting regional vehicle kilometers of travel (VKT) increases that result from regional increases in highway capacity. However, this approach has generally not been fruitful because a variety of extraneous factors can affect the results, including the availability of alternative modes and routes in each corridor; the condition of the local economy (growing or stagnant); zoning; and natural constraints to development. These factors not only affect the conclusions but also limit the validity of extending these results to other situations and locations. Shortcomings of the case study approach are documented in the literature (*3,4*). A brief summary of the reasons for proposing an alternative approach follows.

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Control of Exogenous Variables (Economic Conditions)

Transportation changes take place in a highly dynamic environment: household income, population, employment, fuel and parking prices, and other variables cannot be directly controlled for. A time series approach may not control for the distributional shifts in land use activities that transportation investments may induce if the area of analysis is limited. This creates a considerable problem in distinguishing between a shift along the demand curve (because of the reduced price of travel caused by added capacity), and a shift in the demand curve itself (see Figure 1). Demand curves may shift as a result of changes in income, tastes, and demographic factors. Point 1 represents an initial condition with a four-lane freeway; Point 2 is the result of a capacity increase (travel time reduction) and the associated movement along today's demand curve. Point 3 is purely the result of a demand curve shift, possibly caused by such factors as increased population or income but also possibly caused by reduced transit service, higher fares, or changes in taste. Point 4 is the final equilibrium—a combined result of capacity and demand increase.

Completeness of Data Sets

The data requirements of a case study approach include (as a minimum) annual traffic counts on the new facility and all paralleling routes along with good records of land use changes in the corridor. Local agencies often lack consistent annual count programs with counters at the correct locations to assess changes in corridor demand because of capacity changes. Even if all of the count data were available perfectly, the appropriate temporal resolution needed to assess the impacts of new capacity may be missing. Ideally, counts would be available at 15-min intervals to assess the impacts of temporal shifting in travel, and especially the "peak within the peak." Information needs to be available on all paralleling transit services; even then, one would not know what the changes in destination choices were (were people driving further because of the new capacity to reach a "better" destination?); or the shifts in land uses that took place over time.

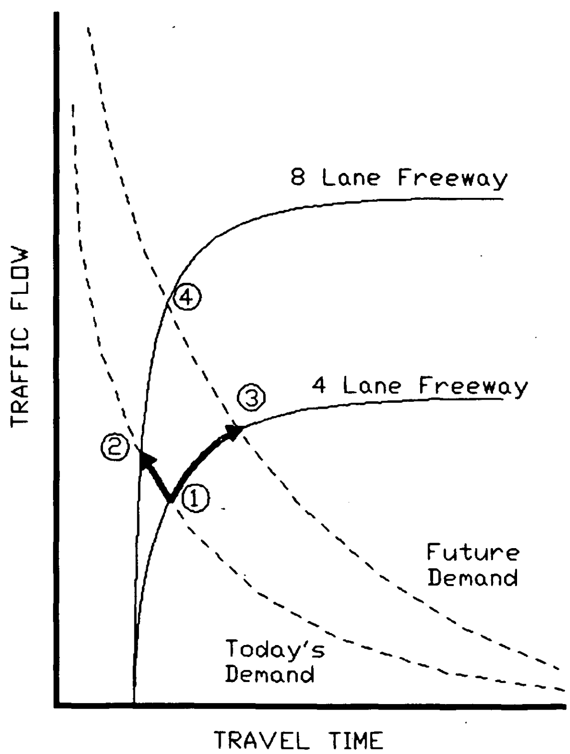

FIGURE 1 Demand versus capacity changes.

Differences in and Comparability of Data Collection Years

Traffic counts, income, and other demographic information typically are not available annually. Most agencies make projections at 5-year intervals, and generally traffic counts are made only at 2- or 3-year intervals (sometimes less often than that). This requires interpolating between demographic data, traffic count, and traffic forecast years. Increased real income and family size (lifecycle issues) typically result in higher levels of automobile ownership and a desire for more residential space. Detailed geographic information at the corridor level is usually available only from the U.S. Census, which is conducted too infrequently (every 10 years) to be useful.

Institutional Bias

Forecasts may contain an institutional bias, perhaps unconsciously. An agency may make reasonable assumptions within a "gray area" of discretion that favors the action that the constructing agency wishes to take. Biases can vary with time, place, and the individuals involved, but can all lead to forecasting errors. An agency could use optimistic or pessimistic views of the economy, of population growth, and so forth.

All of these considerations pointed toward the need for an approach that

- Considers trips in the context of the overall activity patterns of travelers,
- Considers a wider range of alternatives than would be possible to test with the case study approach, and
- Avoids the shortcomings of incomplete data sets, control of exogenous variables, and other limitations noted earlier.

RESULTS OF PREVIOUS RESEARCH

Increased highway capacity may affect travel in a number of ways. In urban areas, new capacity typically reduces congestion, resulting in shorter travel times during some or all of the day, and a less stressful driving experience. In rural areas and small cities, where congestion is minimal, new capacity may or may not change travel times. The literature (*5–8*) documents a strong relationship between reduced travel times and the following short-term effects:

- The choice of the route taken. This effect has been found to be consistently important in the literature. A major assumption underlying the conventional four-step travel forecasting process is that people seek routes that minimize travel time and cost.
- The scheduling of the trip (time of day the trip starts/ends). This effect also has been found to be consistently important in the literature; new highway capacity often has been found to cause

shifts from off-peak or "shoulder" transitional times to the "core" peak periods of travel. This effect was found in examining traffic count data before and after widening of CA-78 in San Diego, the Amsterdam M10 Orbital Motorway (*7*), and other locations.

- The choice of the travel mode used (e.g., carpool, transit, drive alone). This effect has been shown to have a much weaker impact than route and scheduling choice but is still important. The effect is probably more important in the longer term, as changes in automobile ownership and land use take place. Studies of the substantial and sudden capacity reductions caused by the 1989 Loma Prieta earthquake indicate substantial shifts to transit modes (*9*), with about a 10 to 15 percent reduction in the number of total daily person-trips (Markowitz, unpublished data). This reduction is modest compared with the large increase in travel time (often 50 to 100 percent) occasioned by many transbay travelers during the approximately 1-month period when the San Francisco–Oakland Bay Bridge was closed because of the Loma Prieta quake.
- The frequency the trip is made. The literature has been inconclusive on this topic, with some studies indicating significant impacts and others indicating little or no measurable impact. This impact was one of the primary concerns of this project.
- The linking of trips with several destinations together (sometimes known as "trip chaining" or "trip tours"). This appears to be an important impact but has proven difficult to measure and is generally outside the scope of this paper.
- A change in the choice of the destination of a trip; likewise, this impact has proven difficult to measure.

A study of disaggregate household vehicle trip generation rates as a function of proximity to freeway ramps (*10*), using distance as a proxy for accessibility to destinations in 24 urban California counties, was recently made of 6,200 randomly selected households. The study found no significant correlation between the two variables after controlling for other factors. However, this approach had limitations in that distance to the freeway could be measured only as distance to the census tract centroid because survey address records were destroyed (*11*). Furthermore, the results are complicated by the fact that the frequently found convergence of freeways near the core of central cities meant that lower-income residents were often the most proximate to one or more freeway interchanges.

Areawide models (derived by correlating VKT growth to highway system increases) seem more desirable than facility-specific studies because they eliminate the route choice effects by considering entire regions (*11,12*). They are also able to take into account long-term land use effects by extending the analysis over several decades. However, they focus on VKT instead of person-hours of travel and consequently confuse mode shift effects with true induced demand. These studies have been inconclusive about the elasticity of demand (VKT) with respect to new lane-miles of capacity; although all the reported results have been inelastic, they range from a very inelastic 0.1 to a much more elastic 0.8 (*8*).

Even the areawide studies suffer from several critical deficiencies: first, they use a single relatively simple measure of capacity increase (such as lane-kilometers or lane-miles) that is insensitive to the potentially significant different demand effects that would occur if the same investment were made in the center of the region versus the fringes. There are definitional problems in computing the denominator of the elasticity equation; the percentage increase in capacity must be estimated, meaning that a "base" capacity must be measured. Should the base capacity be measured at the corridor, county, primary metropolitan statistical area or consolidated metropolitan statistical area (CMSA) level? Economic theory, as well as experience with transportation and land use forecasting models, indicate that transportation supply cannot be treated as a homogeneous product (*13*).

Common sense suggests that new highway capacity has different impacts in an area that is already "built out" as opposed to one where much undeveloped land exists simultaneously with strong pressures for development. The costs of parcel assembly, structure demolition, and so forth, are simply too high. In most cases the structure built on a parcel of land in the United States is the only one that has ever occupied that piece of property (*14*).

Second, most areawide studies assume a constant elasticity of demand, probably because of the lack of enough data points. Intuition and economic theory suggest that elasticity is not necessarily constant but instead depends on the amount of current congestion and capacity of the system, the time frame involved (short-versus long-term), the trip purposes of road users, and possibly other factors. This issue requires further research.

Because of the problems associated with the case study before-and-after approach (facility specific or areawide), it was decided to use a survey of household travel behavior to isolate the various effects of new highway capacity and identify those effects not currently treated by conventional travel forecasting models. The travel survey and its results are described below.

TRAVEL BEHAVIOR SURVEY

A travel behavior survey was developed and administered to fill in the missing information from the case studies on the relative importance of the different effects of new highway capacity on travel behavior. Each potential effect (mode, time, destination, trip generation) would be identified and quantified for the purpose of determining its relative importance in estimating the total demand effects of new highway capacity.

Selection of Survey Approach

There are two general approaches to conducting behavioral surveys: stated preference (SP) and revealed preference (RP). Other references provide a comparison of these two methods (*15*); briefly, a stated preference survey poses various situations to the interview subject and asks How would you respond to the given situation given certain constraints? A revealed preference survey relies on measurement of actual responses to alternatives existing in the field. RP surveys can test only for the conditions that exist at the time of measurement, but an SP survey can explore behavioral changes because of a much wider range of options. RP surveys traditionally have been used to calibrate travel forecasting models. RP surveys provide information on the actual choices made by individuals in the face of two or more options. RP surveys have several limitations when applied to the problem of estimating the behavioral effects of new highway facilities. Critical shortcomings are the difficulty in avoiding bias in the selection of the survey sample and accounting for persons moving into and out of the presumed "impact" area of the new facility, and controlling for changes in background variables, such as economic and demographic changes.

The major difficulty in applying an SP survey to the research problem is that traditional SP surveys require that the respondent be offered a choice between trip or transportation system attributes that force a realistic trade-off by the user. In a classic SP survey, the respondent is offered a higher fare/shorter travel time option, and a lower fare/longer travel time option. With increased highway capacity/reduced congestion, such a trade-off is not possible because presumably everyone would prefer a shorter travel time. To make meaningful tradeoffs between alternatives, respondents were asked to describe all of their previous day's activities and then contemplate how they would alter them if more (or less) time were available on that day to perform those activities. Perhaps more precisely, it is how people would use "released" or "freed-up" time, if congestion-relief projects made such time available.

The survey also embodied concepts from the developing field of activity analysis (*16*). Within the survey instrument here, people were asked about all of the previous day's activities and then asked to respond to changes in travel and activity patterns given changes in travel time for trips made on the reference day. Although the 24 hr available each day is fixed for every individual, the allocation of time to each activity is not. The time and money allocated to travel is further subdivided among mandatory activities such as going to work, school, and so forth, and discretionary activities such as going to a movie. These various daily activities can be thought of as "goods" in the economic sense that people "purchase" by spending "time" and money on the activity. A 1987 survey (*17*) found that the average California adult spends 1.8 hr a day traveling, more than 10 percent of his or her waking hours.

Each survey respondent was told the following:

> We are trying to find out how traffic congestion affects what people do. I am going to describe what might happen if traffic congestion got better or worse, and ask you how you might change your activities or travel as a result. Please take some time to think carefully about what you might do.

The respondent was then read back all of the trips he or she made the previous day, and asked,

> Consider what you told me about what you did yesterday. For each trip I am going to ask you what you would have done if it had taken less time to make the trip. Consider your first trip yesterday. You started at . . . [time] and went to . . . [destination] by . . . [mode]. This trip took . . . [duration previously stated by respondent]. Now suppose that this trip took [randomized duration] less time to make. Please select one or more of these statements that best describe what you would have done.

Respondents were not asked about trips that were less than 10 min in duration, because the minimum travel time savings "offered" was 5 min, and it was thought that for trips of less than 10 min, a time savings of 50 percent or more would be unrealistic and unlikely to be achieved by any plausible capacity-increasing project and also because of the desire to offer travel time savings in increments of 5 minutes. In fact, one of the survey problems was that the total travel time change was independent of the individual's reported trips. Also the total released time during the day was not keyed to a specific hour, which some respondents indicated would condition their response of how the time would be used.

Survey Methodology

Adults over the age of 16 in the San Francisco and San Diego metropolitan areas were randomly selected; these two areas contain about 8.7 million people. Respondents were interviewed about their existing travel behavior, activity patterns, and hypothetical behavior under changes in travel time. "Number plus one" dialing was used to reach unlisted numbers. The Los Angeles area was excluded because the Northridge earthquake occurred shortly before the survey commenced and had dramatically affected travel patterns there. The survey was administered using computer-assisted telephone interviewing (CATI) because of the complex branching required in the survey. Interviews were conducted on Tuesday through Friday evenings and Saturday midday, with survey questions asked about the prior day's travel. Randomization techniques were used to ensure that the person who answered the phone was not necessarily the person interviewed.

After all trips were enumerated, the CATI program selected each trip made that was at least 10 min long. For trips between 10 and 15 min, a 5-minute reduction in travel was offered. For trips longer than 15 min, a randomized travel time savings of between 1 and 50 percent was offered; the randomized savings was a minimum of 5 min if the survey number was odd and 10 min if the survey number was even.

Survey respondents were given the following options: doing nothing differently; starting at the same time and arriving earlier; starting later and arriving at the same time; changing mode; changing trip destination; making an extra stop along the way; and "other." Only one additional "extra stop" was allowed for in the questionnaire, although in reality it is possible that some individuals might add two (or more) trips to their tour. The possibility of entirely new trips was allowed for at the end of this process by asking, Would you have left home again before the end of your day if you had [randomized time] minutes extra time? If the answer was yes, the respondents were asked where they would have gone, how much time they would have spent there, and for what purpose.

Survey Results

A total of 676 individuals over the age of 16 were interviewed in 676 households. They collectively made a total of 2,182 trips the previous day. The respondent demographics (age, income, educational achievement, and automobile ownership) were compared with those from the 1990 Census. The respondent pool was close to the state average, except that poor households (those earning under $15,000 per year) were somewhat underrepresented. About 90 percent of the respondents were willing to report their household income. Of those answering the question, 9.5 percent reported household incomes under $15,000 per year. The 1990 Census found the same group constituted 15.1 percent of the households in the San Francisco Bay Area (CMSA). Some of the difference can be accounted for by inflation between 1989 (the reference year for the census) and the year of the survey (1994).

Very-low-income groups tend to be underrepresented in most telephone surveys, but the importance of these households is mitigated by the fact that they produce a small percentage of VKT. The National Personal Transportation Survey (*18*) found that households with incomes under $10,000 generate VKT/household that is only 40 percent of the average rate for all households (using automobile driver miles as the measure). The 1990 Census found that these households represent about 15.5 percent of all households in the United States; therefore, it appears that they are responsible for somewhat over 6 percent of VKT.

The key results of the survey (Tables 1 and 2) were as follows:

TABLE 1 Responses of Travelers to Travel Time Savings for Each Trip

	Travel Time Savings due to Congestion Relief (minutes)				
Response	5	10	15	20+	All
No Change	46.5%	49.6%	35.1%	38.1%	46.5%
Arrive Earlier	34.9%	33.9%	40.5%	31.0%	34.6%
Leave Later	12.9%	12.5%	16.2%	23.8%	13.5%
Change Mode	0.4%	0.4%	2.7%	2.4%	0.6%
Change Destination	0.9%				0.5%
Make Extra Stop	2.9%	2.8%	5.4%	4.8%	3.1%
Other	1.5%	0.8%			1.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

- Over 35 percent of the trips made would be unaffected when the trip travel time increased or decreased by 15 min or less considering all trip purposes.
- Another 20 to 40 percent of trips made would change only to the extent that the respondent would arrive earlier or later at a destination and make no change to the departure time to compensate for the effect of the travel time change.
- About 10 percent to 15 percent of the trips would be rescheduled to compensate for or take advantage of the travel time change.
- A time savings of 5 min would generate extra stops for about 3 percent of the trips. This percentage increased to 5 percent when a 15-min time savings was offered. The average across all time savings offered was 3 percent.

The overall result is that 90 percent to 95 percent of the trips would be unchanged or would have schedule changes in response to travel time increases and reductions of 15 min or less. As expected, the greater the magnitude of the travel time change, the greater the traveler response. Interestingly, the results are not symmetrical: respondents tended to react slightly more strongly to increases than to decreases in travel time (see Figure 2). When faced with a travel time increase, respondents would try to adapt by changing mode, destination, and route for a higher percentage of the trips than if they were offered an equal amount of time decrease. Given the nature of the two metropolitan areas in which the survey was conducted, it is likely that more respondents had recent experience adjusting to travel time increases than decreases. Asymmetric behavior is probably not surprising; some gaming simulations have shown that even given the same actuarial odds (expected value), people are much more concerned with a possible loss of wealth than they are with a possible gain.

TABLE 2 Responses of Travelers to Travel Time Increases for Each Trip

	Travel Time Increase due to Congestion (minutes)				
Response	5	10	15	20+	All
No Change	53.5%	41.3%	38.6%	24.4%	45.7%
Arrive Later	22.1%	31.0%	38.6%	36.6%	27.8%
Leave Earlier	17.3%	17.6%	9.1%	24.4%	17.4%
Change Mode	1.2%	1.5%	4.5%	2.4%	1.6%
Change Destination	1.0%	0.4%	2.3%		0.7%
Make Extra Stop	0.2%	1.3%			0.7%
Other	4.6%	6.9%	6.8%	12.2%	6.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

The respondents indicated that only approximately 1.6 percent of their trips would be susceptible to a modal change given increased travel time for a specific trip. Of these hypothetical "mode switchers," most (38 percent and 35 percent, respectively) said they would switch to driving alone or public transit. It was implicit in the survey that the travel time by alternative modes was not changed. Greater time increases and decreases had a greater effect on traveler responses than smaller amounts of time changes. However, given that only 13 percent of survey trips were greater than 30 min in length, it was not realistic to ask the majority of the respondents about time savings of greater than 15 min.

CONCLUSIONS AND RECOMMENDATIONS

Most previous investigations of the effects of new highway capacity have been facility-specific "before-and-after" studies. At first, this approach seems appealing and logical, but on reflection, it becomes clear that it is nearly impossible to isolate the effects of new highway capacity on induced trip making. There are too many extraneous factors that can affect the results, including the availability of alternative modes and routes in each corridor; the condition of the local economy; zoning; and natural constraints to development. These factors not only affect the conclusions but also limit the validity of extending these results to other situations and locations. These factors may have been responsible for the conflicting conclusions that other researchers frequently arrived at in the past.

The results of this survey must be qualified by its relatively small size (under 700 households) and limited geographic scope. However, the following are some of the indications from this survey:

- Current travel forecasting practice probably results in an underprediction of 3 to 5 percent in the number of trips that may be induced by major new highway capacity projects. Where a project is expected to yield travel time savings of more than 5 min for a large number of trips, adjusting travel demand upward to reflect induced travel is probably warranted.
- A key impact of new highway capacity is temporal shifts in demand (trips formerly made in the off-peak moving to the peak periods). From the highway user's perspective, this is not necessarily bad because it means that he or she can make a trip in response to personal needs rather than to traffic conditions. On the other hand, it will affect the congestion, speeds, and emission estimates produced by travel models. There is a strong need to develop better models to predict peak spreading/time of day of travel.

In the longer term, new highway capacity may influence decisions about automobile ownership, residential location, employment location, and the locations of expansion areas for businesses and government. These effects are important but are beyond the scope of this paper. Several of these effects cannot be addressed with a household travel behavior survey. However, some of these impacts are already accounted for in current transportation/land use forecasting practices in California's largest metropolitan areas, using models such as DRAM/EMPAL and POLIS.

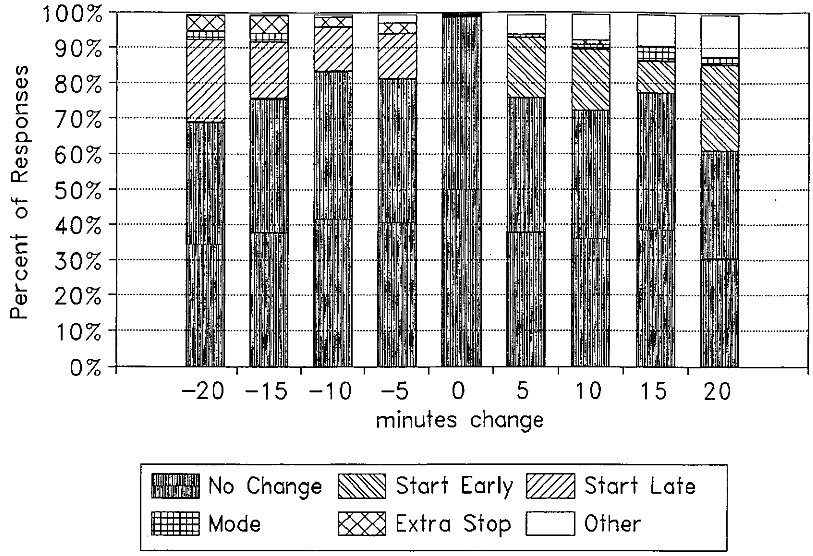

FIGURE 2 Response of travelers to hypothetical trip time changes.

Key Conclusions

Highway capacity changes influence travel behavior principally by affecting travel time and cost. The principal conclusions from the survey are as follows:

- The sample indicated definite preferences about how travelers would respond to changes in travel time. Their response preferences are in the following order:
  - Change route (find a faster route if the current one becomes congested);
  - Change schedule (find another time of day when congestion is lower);
  - Consolidate trips (reduce number of daily trips by accomplishing more activities with a given trip);
  - Change mode (switch to more convenient mode); and
  - Change destination (find another location with similar services).
- Whether a person prefers to change mode over destination (or vice versa) may depend on the trip purpose, for example, a destination change is probably preferred over a mode change for most shopping trips.
- The order of preference responses appears to be similar for travel time increases and decreases, although the magnitude is different. Whether faced with travel time increase or decrease, both changes would result in the respondent preferring a different route or rescheduling the trip, rather than changing the trip mode or destination.
- Survey respondents indicated a high degree of resistance to change in their travel behavior when offered travel time savings of between 5 and 15 min per trip. A 5-min travel time savings (on average) resulted in a 3 percent increase in daily trips made per person and a 15-min time savings resulted in a 5 percent increase in trips per person per day.

Because most trips in metropolitan areas are less than 15 min long and realistic time savings on such short trips would rarely exceed 5 min, it is unlikely that adding new lanes to an existing highway would significantly reduce travel times for the majority of trips, although this general observation may not apply to new highways or to home–work (commute) trips. Commute-related trips are longer at an average of between 20 and 30 min and are more likely to encounter peak-period congestion. The commute trip also drives many other decisions, such as vehicle holdings and household location, and those considerations have a substantial influence on generation of short trips. Thus, there could be some important secondary impacts that are not accounted for here.

Recommendations for Future Research and Survey Improvement

There were questions that could not be answered in this study. They include assessing whether the results are transferable to other areas; how congestion affects interactions between household members; and how qualitative factors (such as stress) may influence travel behavior when congestion is reduced. It seems logical to presume that a 30-min drive in stop-and-go traffic would be perceived differently from a 30-min drive in free-flowing traffic, but the survey instrument was not able to distinguish between the two. A small sample of commuters in Orange County, California (*19*), found that most, but not all, drivers perceived commuting in congested traffic as more stressful than commuting in uncongested traffic. To the extent that this is true, it suggests that the results of the travel survey conducted here could underestimate the true effects on tripmaking of reduced congestion.

It is recommended that the following steps be taken to improve the understanding of the effects of increased highway capacity on travel behavior and to improve the ability to forecast these effects at the regional level. Repeating the behavioral survey in other metropolitan, and possibly rural, areas to determine whether the survey results can be reliably extrapolated to all travelers would be desirable. A larger survey sample would also yield more information on the effect of new highway capacity on various trip types and purposes.

The wording of survey questions and presentation of alternatives are critical in most SP surveys and are among the known weaknesses of the method. Some respondents were confused about whether a visit to a different location meant a different location for the same purpose or a different location for a different or additional purpose. For some respondents who made fairly short trips, the total travel time savings presented was near or greater than the amount of time the respondent had reported in travel. Some respondents who realized this were confused.

This survey did not allow for the possibility that people could save a trip time reduction over a week, and "spend" it as a block. The survey approach was thought to be appropriate since, unlike money, time is not easily "banked." However, the authors recognize that the greater an individual's flexibility in allocating time, the more likely that travel time savings should be investigated using a week as the reference period (rather than 24 hr). Nonworkers or those working part time would appear to have the greatest flexibility in this regard (the increasing use of 4-day work weeks may also be important).

It would be useful to use other research approaches to corroborate the results of this survey. One is activity gaming and simulation, which allows researchers to better understand the intrahousehold allocation of travel and other activities. This study made only a rudimentary attempt to consider how one household member's travel time changes might affect the travel and activity patterns of other members of the household. Another approach would be to collect detailed information on the before-and-after effects of those living in a corridor where travel times are improved. Recently developed automatic vehicle location technology, using cellular phone technology, would allow detailed multiday travel diaries to be analyzed without the tedium and error associated with the traditional manually kept diaries.

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